

Magnesium-Rich Coatings

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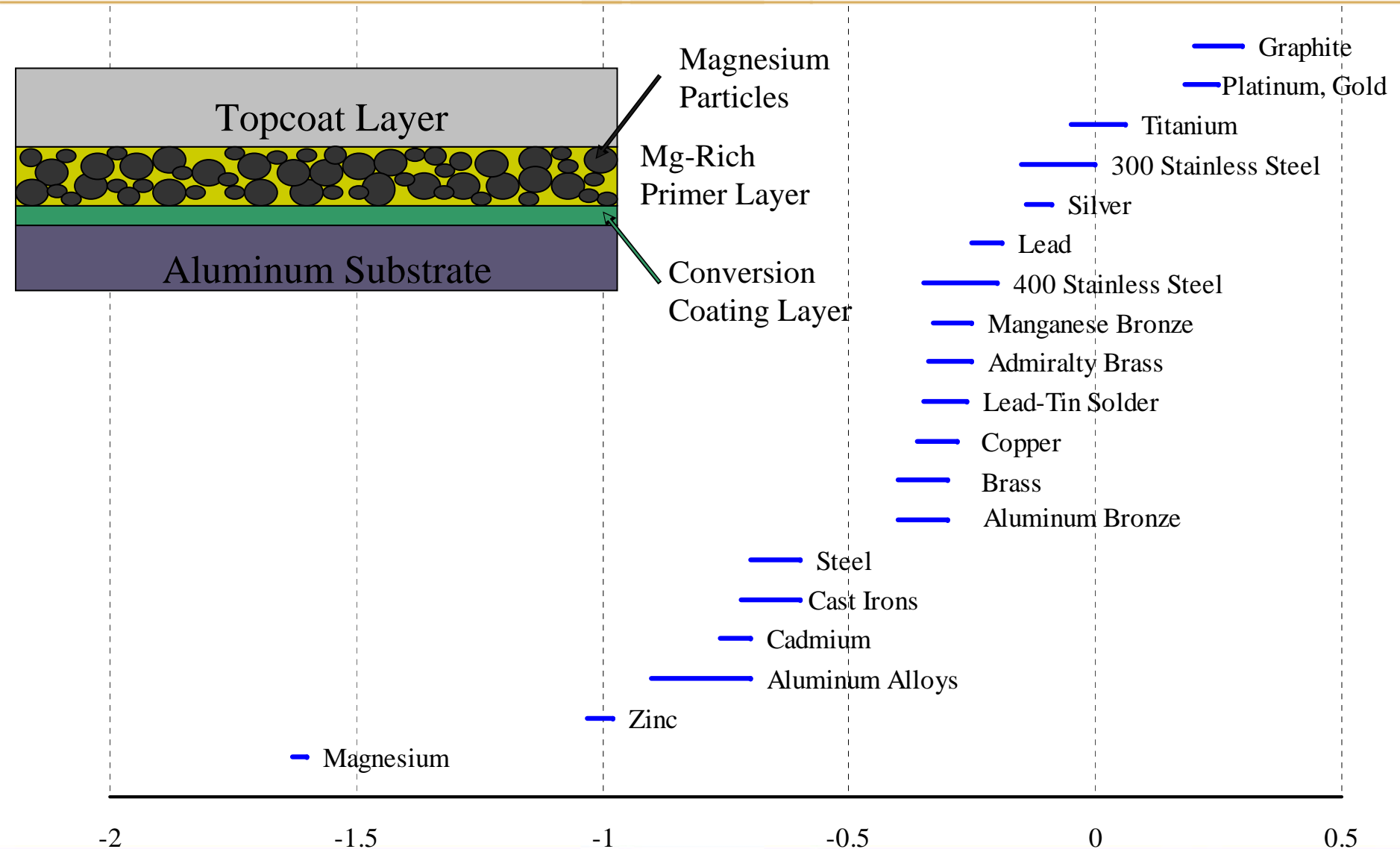
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Introduction

- Hexavalent chromium compounds (chromates)
 - “Gold” standard in corrosion prevention
 - Regulatory, environmental and health issues
- Hexavalent chromium elimination efforts
 - Can simplify paint/depaint, decrease the cost
 - Have led to increased corrosion failures
- Much work has been done on chromate-free protection systems
 - No non-chromated primer equivalent performance



Introduction



Test Plan

- Substrates
 - AA2024-T3
 - AA7075-T6
 - AA2219-T87
 - AA2024 Al clad
- Primers
 - Mg-Rich (Multiple Formulations)
 - MIL-PRF-23377 Class C2
 - MIL-PRF-23377 Class N
 - MIL-PRF-85582 Class N
- Conversion Coatings
 - MIL-DTL-81706 Type I
 - MIL-DTL-81706 Type II
 - None (Scotchbrite™ abraded)
- Tests
 - Beach-Front Exposure
 - Salt Fog Exposure
 - Filiform Corrosion



Beach-Front Testing



Kennedy Space Center
Beach Corrosion Test Site
100 feet from mean high-tide
Panels racked 30° from horizontal



Accelerated Testing

ASTM Standard Test Methods

B 117: Neutral Salt Fog

G 85, Annex 4: SO₂ Salt Fog



Accelerated Testing

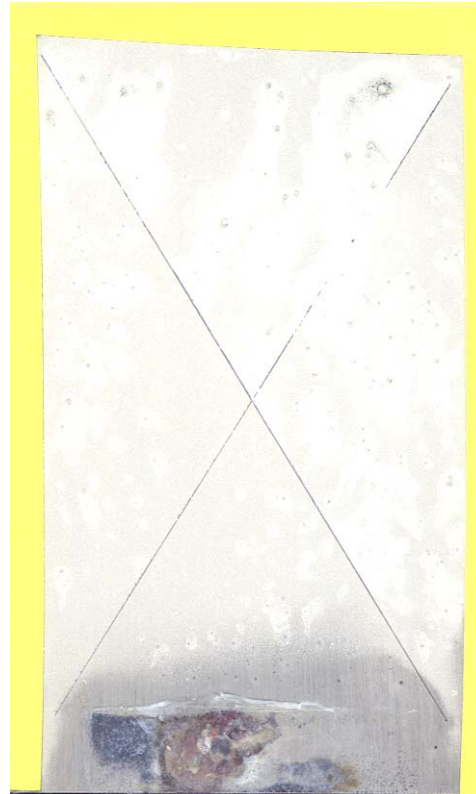


First Generation Test Results

AA2024-T3 (4000 hours B117) – MgRich Primer-only



MIL-DTL-81706 Type I –
Alodine 1200S



No Chemical Pretreatment
Scotchbrite Abrade

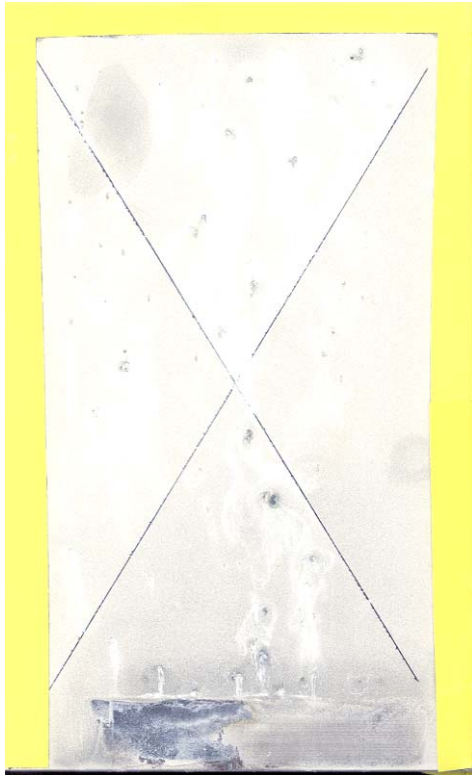


MIL-DTL-81706 Type II –
Alodine T5900

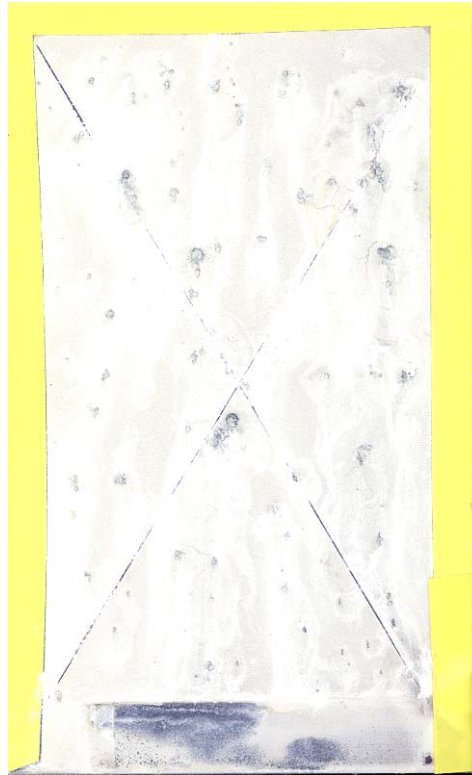


First Generation Test Results

AA2219-T87 (4000 hours B117) – MgRich Primer-only



MIL-DTL-81706 Type I –
Alodine 1200S



No Chemical Pretreatment
Scotchbrite Abrade



MIL-DTL-81706 Type II –
Alodine T5900



First Generation Test Results

AA2024-T3 (1200 hours G85 A4) – MgRich Primer-only



MIL-DTL-81706 Type I –
Alodine 1200S



No Chemical Pretreatment
Scotchbrite Abrade



MIL-DTL-81706 Type II –
Alodine T5900



Second Generation Test Results

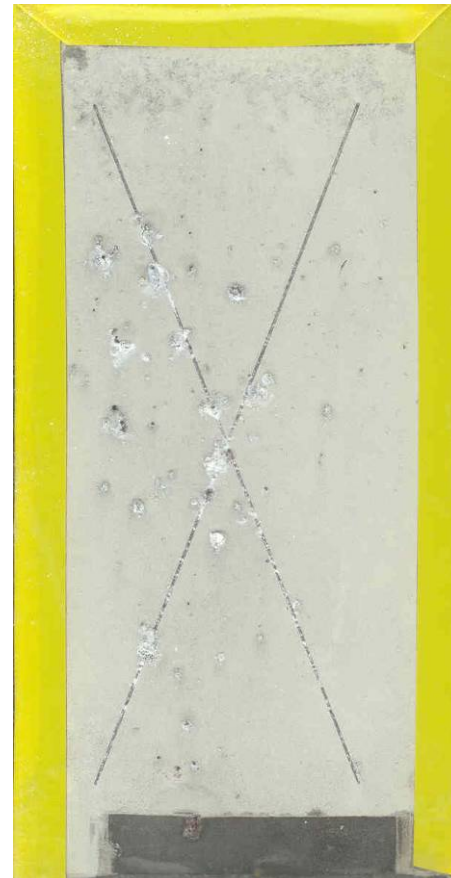
AA2024-T3 (1200 hours G85 A4) – MgRich Primer-only

Gen 1



MIL-DTL-81706 Type I –
Alodine 1200S

Gen 2



MIL-DTL-81706 Type I –
Alodine 1200S

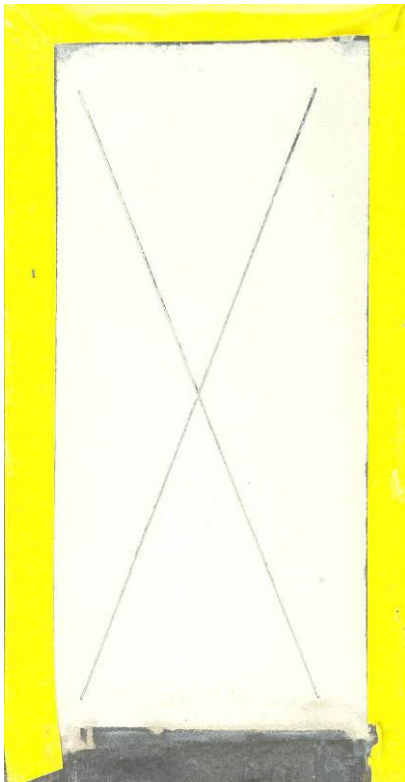


Second Generation Test Results

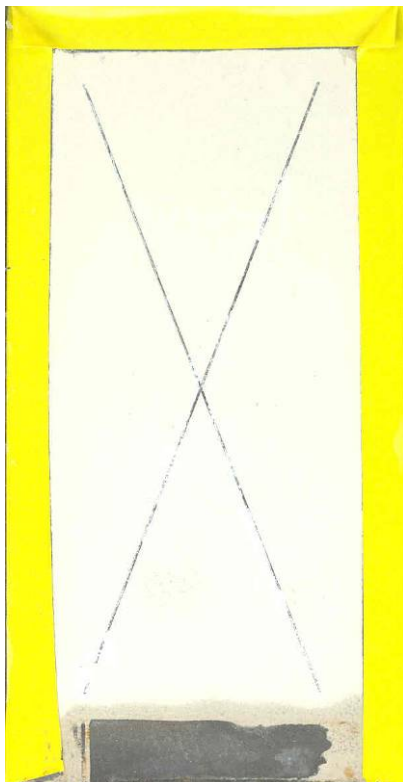
Primer-only panels (5000 hours B117)

Mg-Rich Primer

AA2024-T3

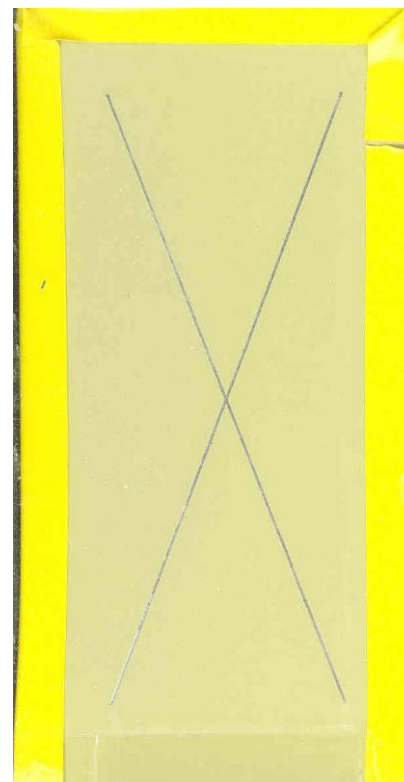


AA7075-T6

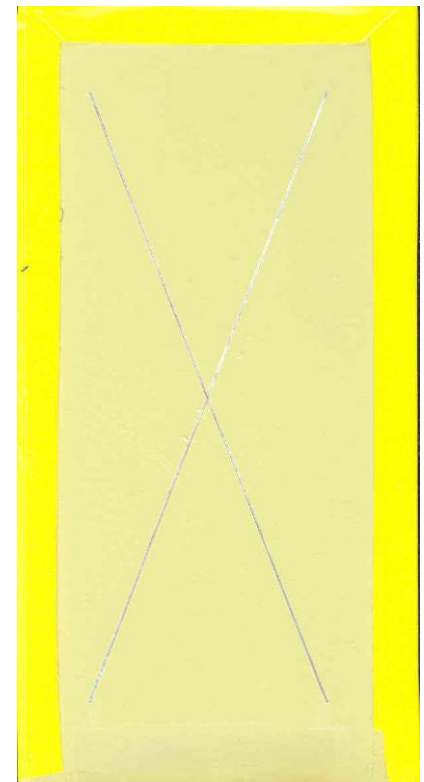


MIL-PRF-23377, Class C2

AA2024-T3



AA7075-T6



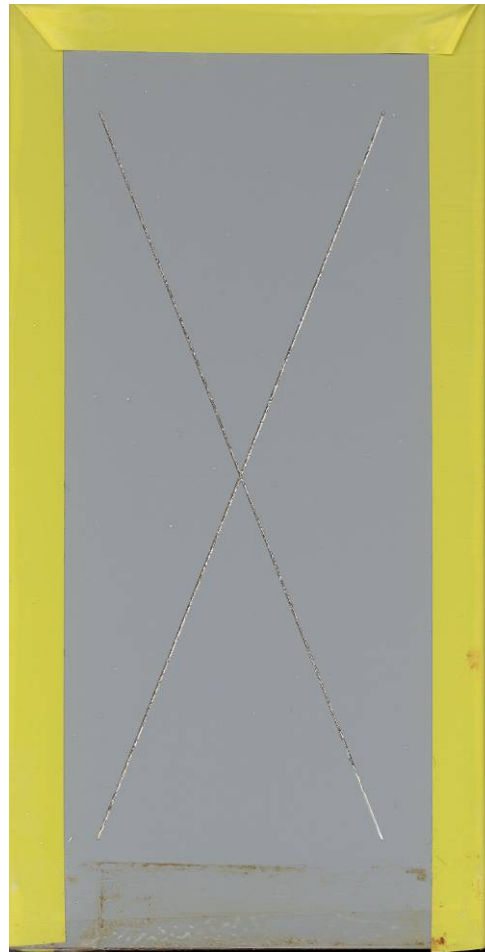
Second Generation Test Results

MIL-PRF-85285 topcoated Mg-Rich panels (ASTM B117)

AA2024-T3



AA7075-T6



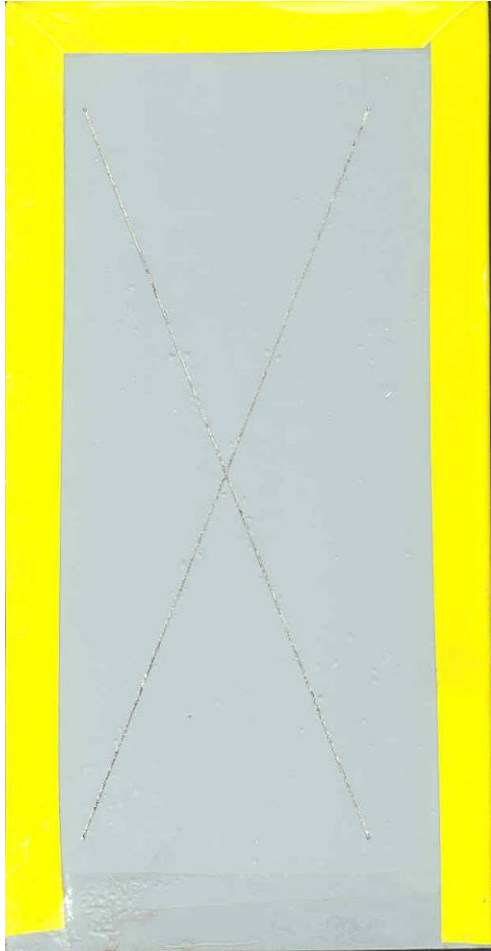
1 Week
(170 hours)



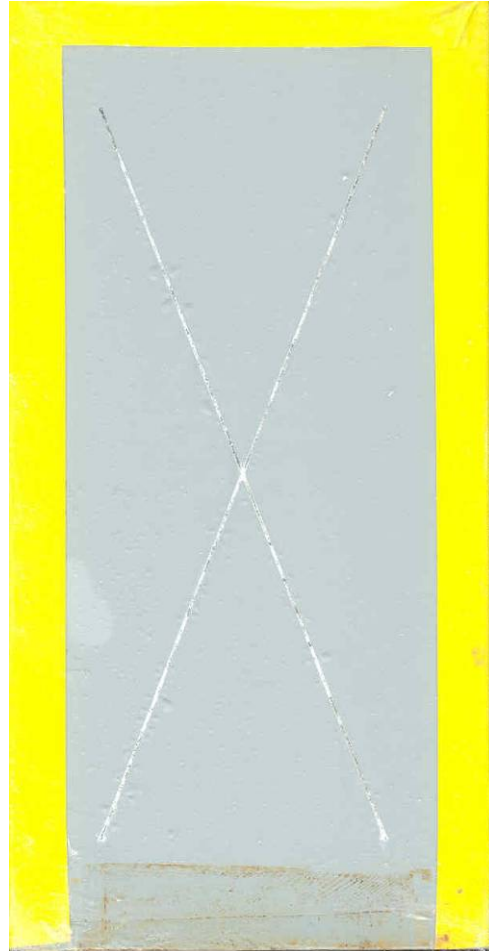
Second Generation Test Results

MIL-PRF-85285 topcoated Mg-Rich panels (ASTM B117)

AA2024-T3



AA7075-T6



12 Weeks
(2000 hours)



Second Generation Test Results

MIL-PRF-85285 topcoated Mg-Rich panels (ASTM B117)

AA2024-T3



AA7075-T6



30 Weeks
(5000 hours)



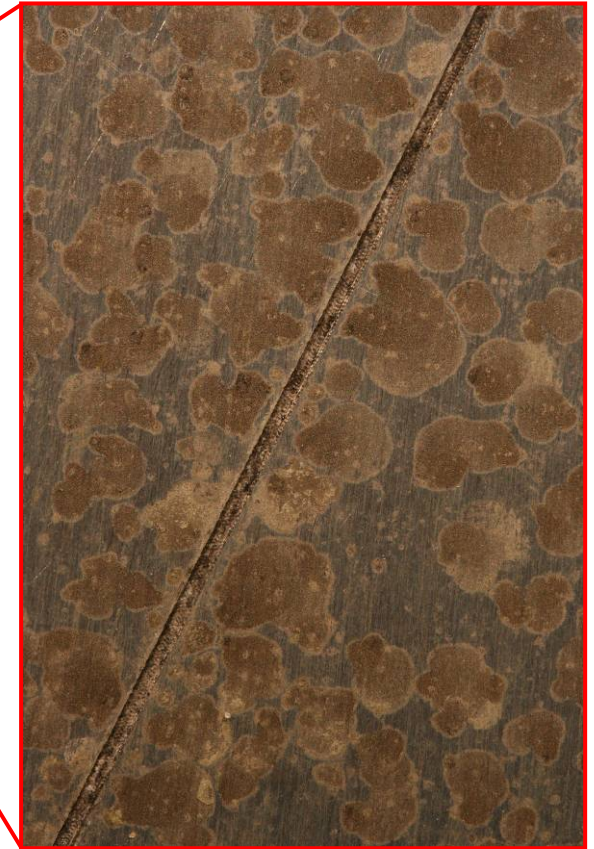
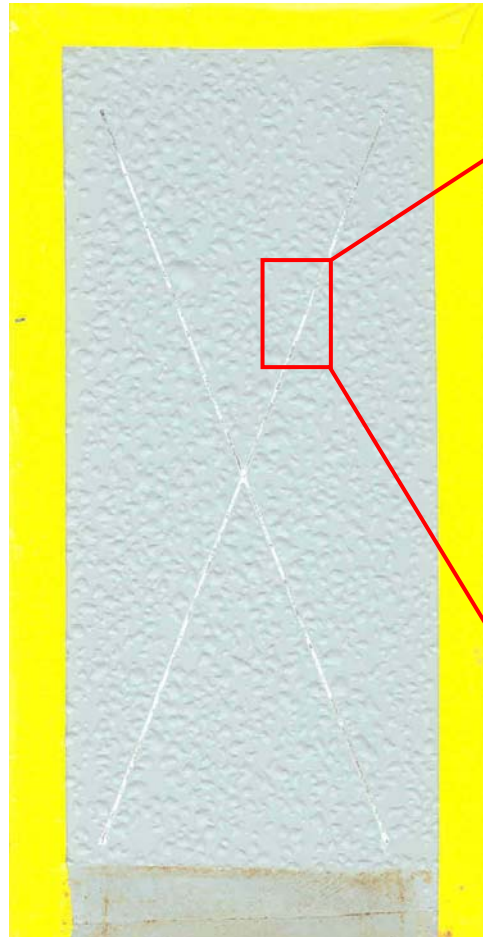
Second Generation Test Results

MIL-PRF-85285 topcoated Mg-Rich panels (ASTM B117)

AA2024-T3



AA7075-T6



Second Generation Test Results

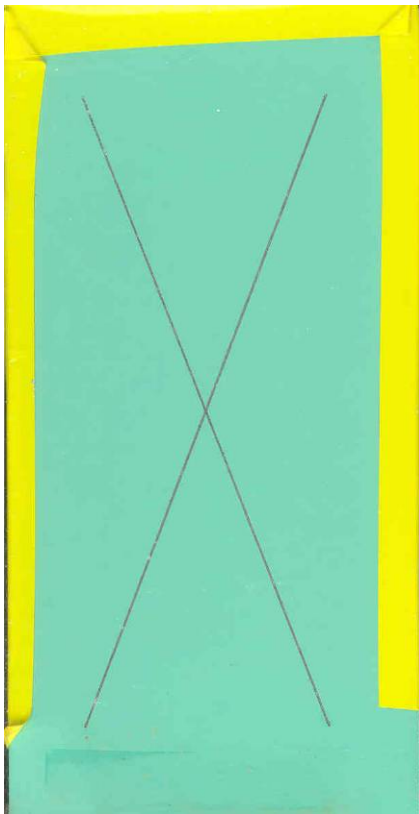
AA7075-T6 (336 hours G85 A4) – MgRich Primer-only

MIL-DTL-81706 Type II

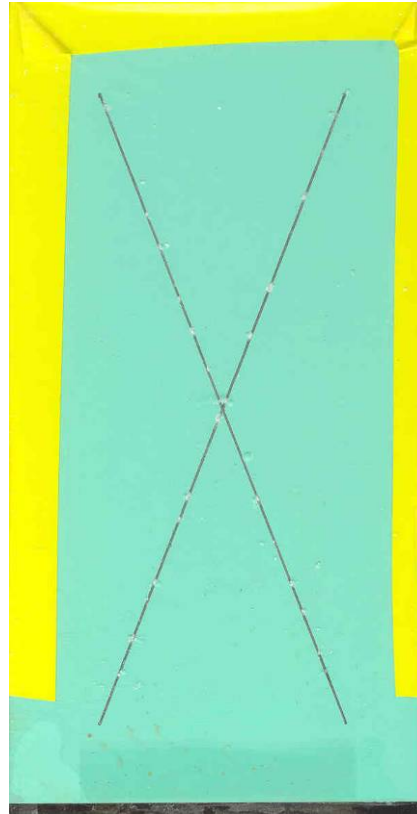
Mg-Rich Primer



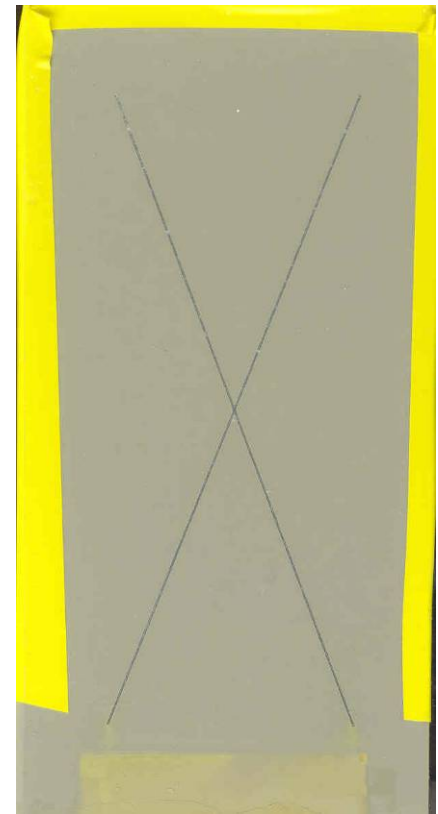
MIL-PRF-23377 Class N



MIL-PRF-85582 Class N



MIL-PRF-23377 Class C2



Second Generation Test Results

AA7075-T6 (1500 hours G85 A4) – MgRich Primer-only

MIL-DTL-81706 Type II

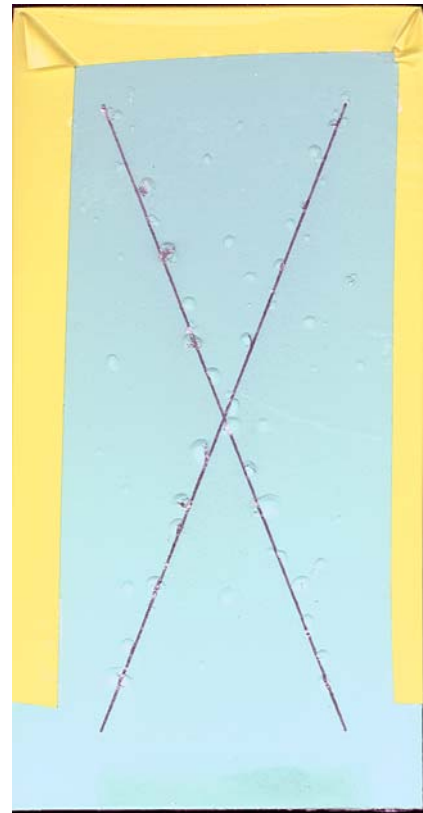
Mg-Rich Primer



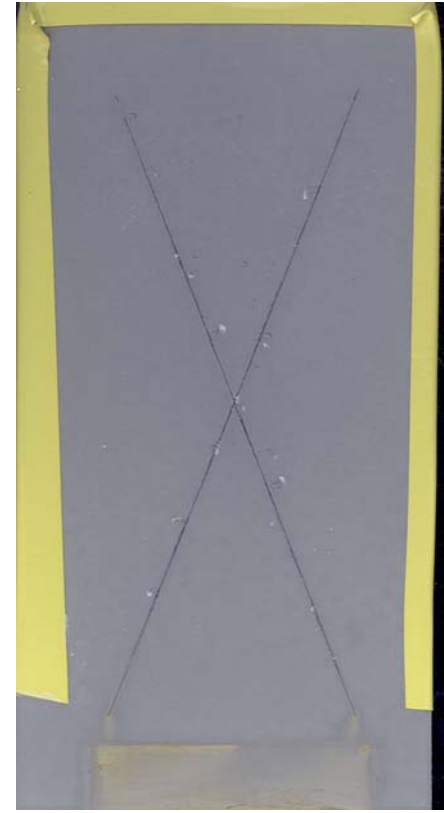
MIL-PRF-23377 Class N



MIL-PRF-85582 Class N

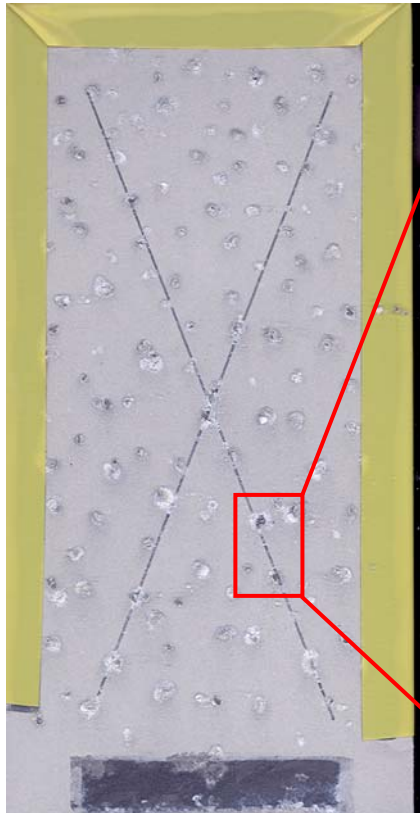


MIL-PRF-23377 Class C2



Second Generation Test Results

Mg-Rich Primer



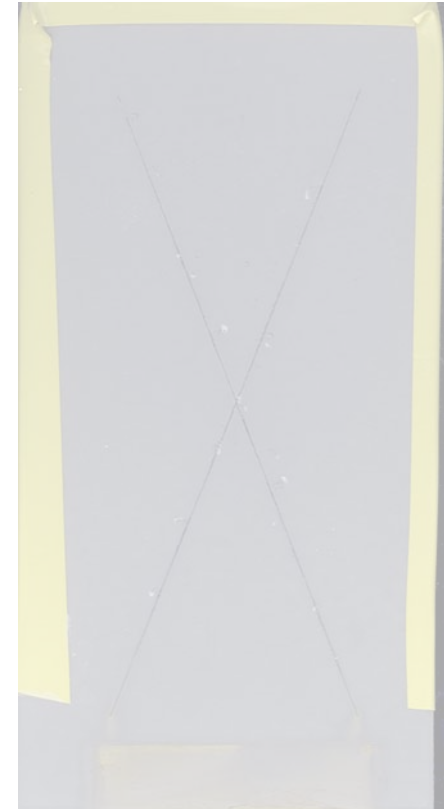
Non



82 Class N
m Primer



MIL-PRF-23377 Class C2
Hexavalent Chromium Primer



Second Generation Test Results

MIL-PRF-85285, (1500 hours G85 A4)

MIL-DTL-81706 Type II

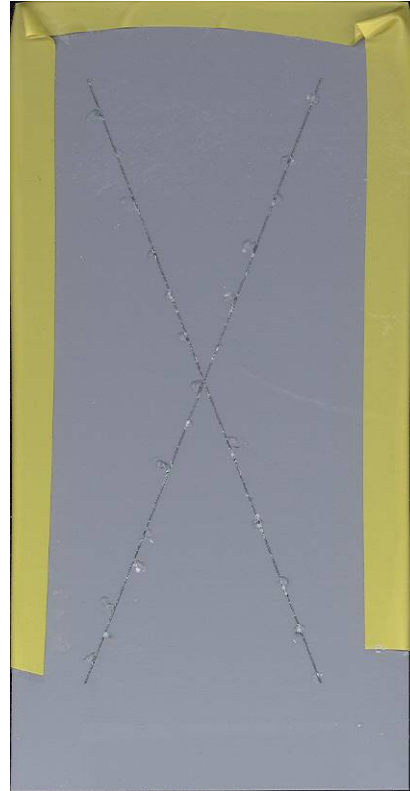
Mg-Rich Primer



MIL-PRF-23377 Class N



MIL-PRF-85582 Class N



MIL-PRF-23377 Class C2



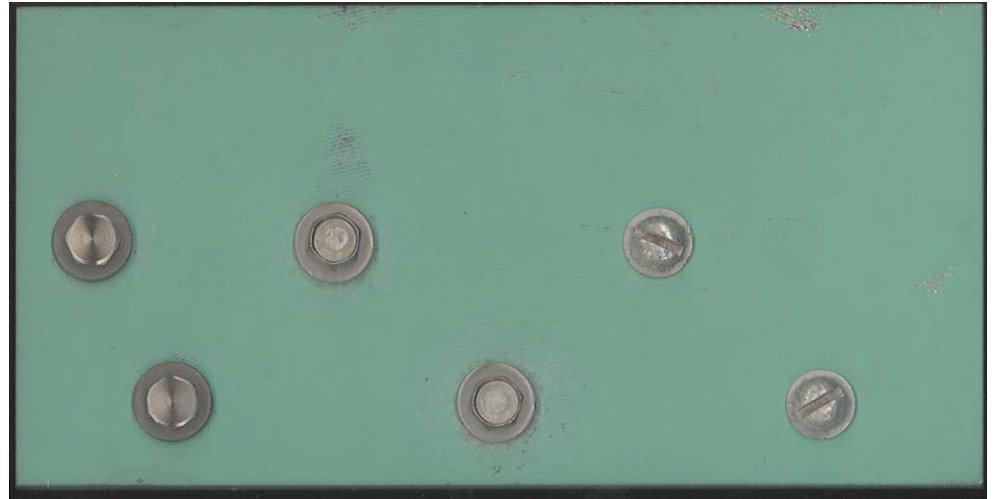
Second Generation Test Results

AA2024-T3 Galvanic panels – Primer-only – 4 month KSC Beach



Mg-Rich Primer

Aluminum test panels with titanium, stainless steel and aluminum bolts.



Class N Control



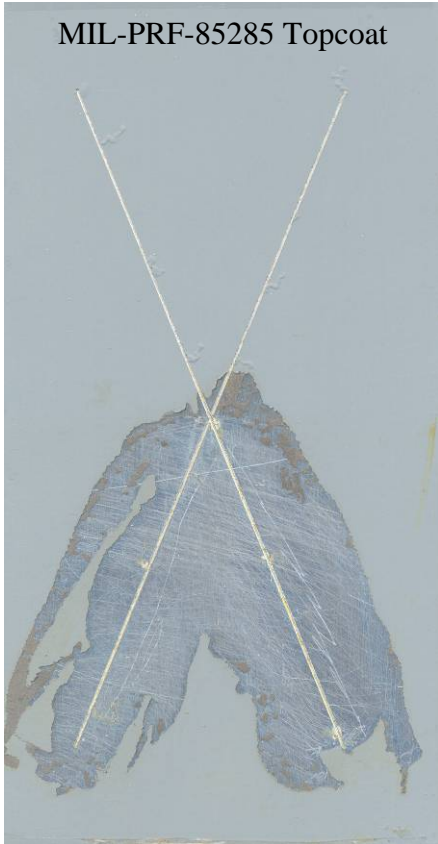


Second Generation Test Results

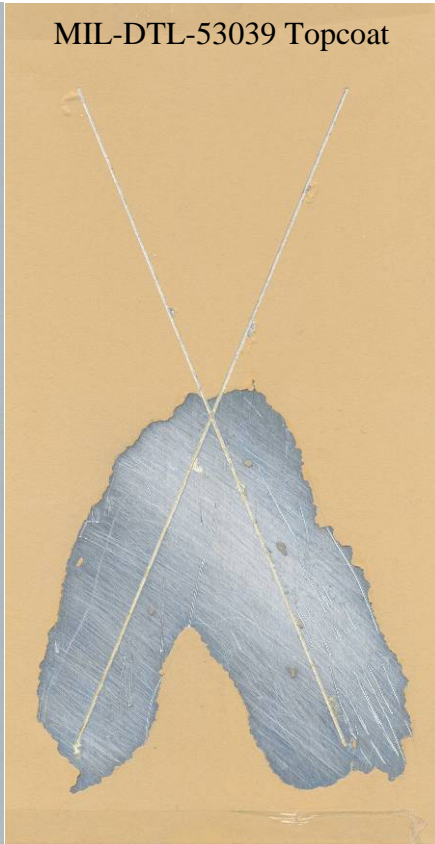
Filiform corrosion test (1000 hours) – MIL-DTL-81706 Type II

Mg-Rich Primer

MIL-PRF-85285 Topcoat



MIL-DTL-53039 Topcoat



MIL-PRF-23377 Class C2

MIL-PRF-85285 Topcoat



MIL-DTL-53039 Topcoat



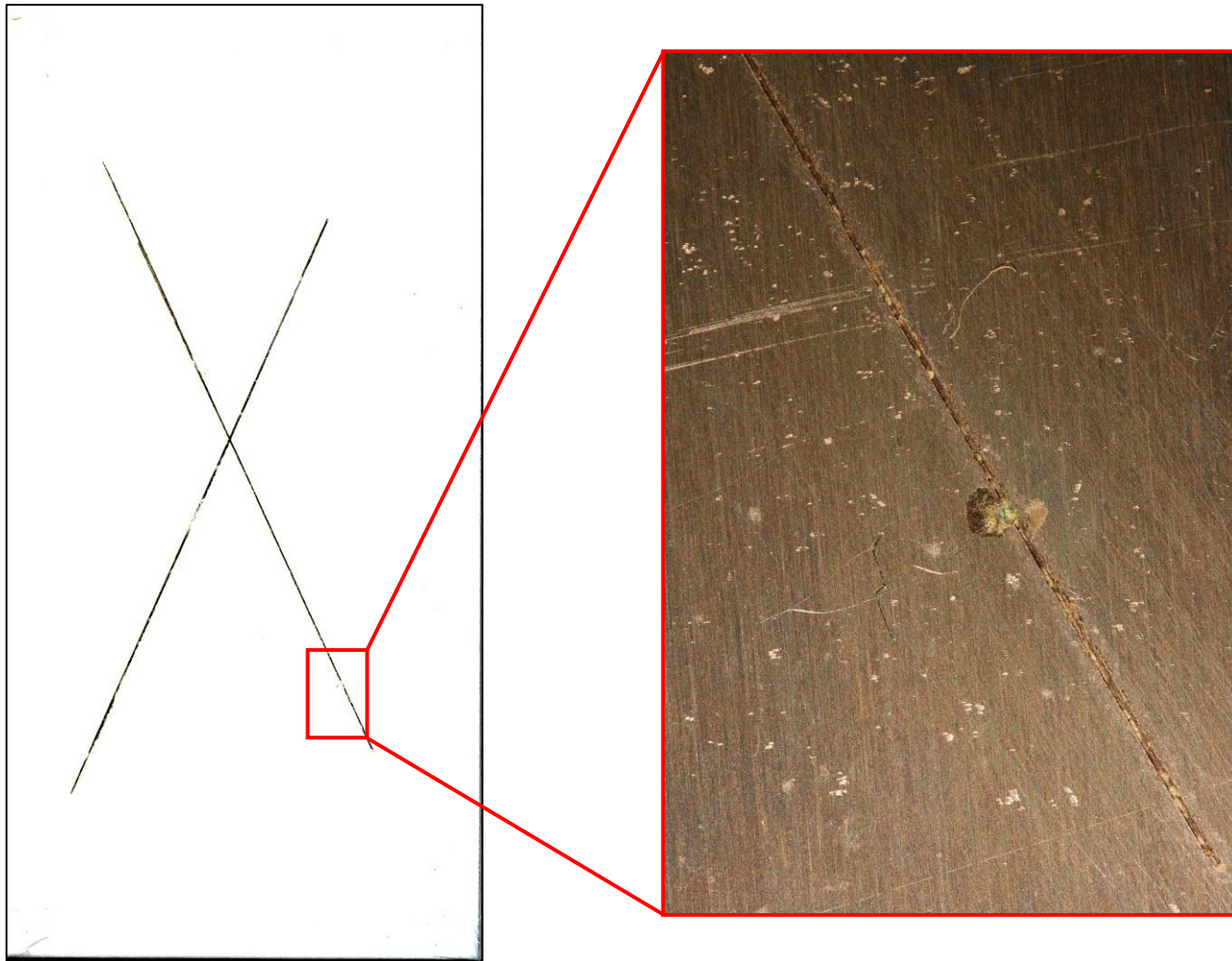
Third Generation Test Results

AA2024-T3 (2000 hours B117) – MgRich Primer-only



Third Generation Test Results

AA2024-T3 (2000 hours B117) – MgRich/MIL-PRF-85285

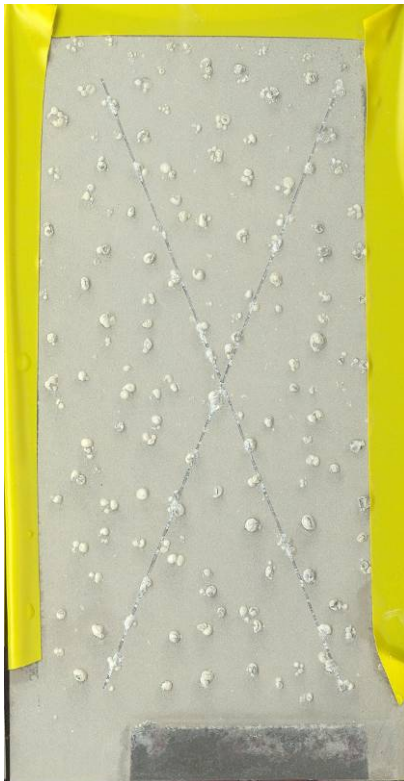


Modifications to Second Generation Mg-Rich

AA7075-T6 (1000 hours G85 A4) – MgRich Primer-only

NAVAIR Non-chromium pretreatment

Second Generation
Mg-Rich



Modification 1



Modification 3

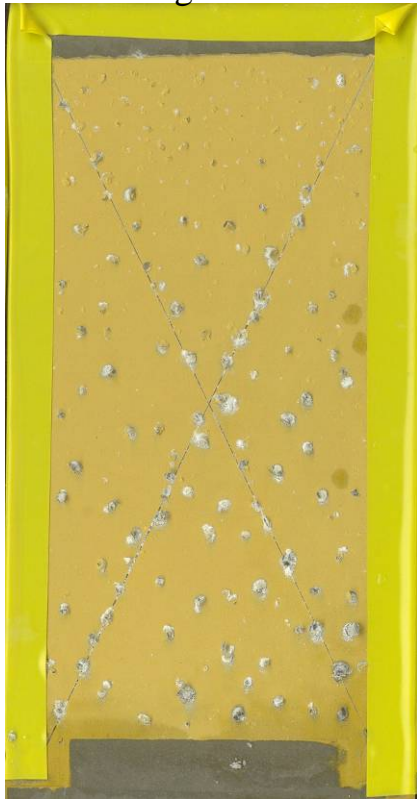


Modifications to Third Generation

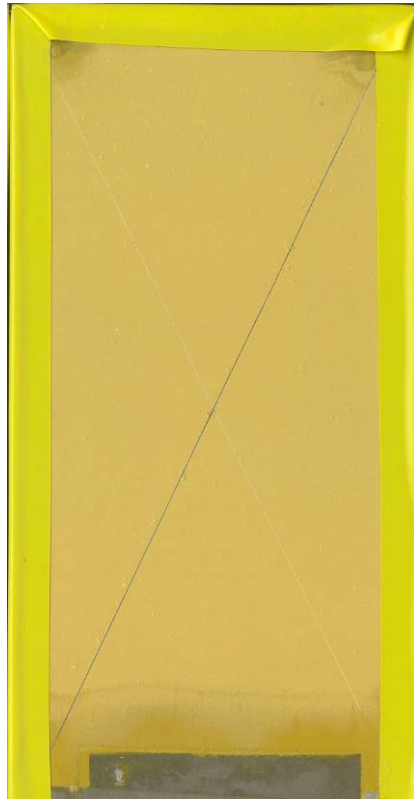
AA7075-T6 (1000 hours G85 A4) – MgRich Primer-only

MIL-DTL-81706 Type II

Third Generation
Mg-Rich



Modification 1



Modification 2



MIL-PRF-23377 Class N



Summary & Conclusions

- No single, universal test for corrosion prevention
 - Multiple alloys, test methods and configurations
- Promising performance – MgRich does well
 - Primer only in neutral salt fog (5000 hours)
 - Topcoated in SO₂ salt fog (1500 hours)
 - Filiform corrosion tests (1000 hours)
- Challenges – MgRich issues not seen with Class N controls
 - Topcoated in neutral salt fog
 - Primer only in SO₂ salt fog
 - Downglossing of High-gloss topcoats
 - Performance degradation on non-2000 series alloys
 - Poor corrosion performance on steel
 - Validation over anodize, Cd, ZnNi, IVD-Al, phosphate, etc.



Summary & Conclusions

- Under certain conditions
 - Mg-Rich primer performs comparably to chromate primers
 - Overall it is not equivalent to chromated OR non-chromated control primers
- Modifications have increased performance over various substrates
 - Fewer ruptures through the coating and blisters
 - Compared to the baseline early generation MgRich primers
 - Fewer blisters and corrosion products in the scribe



Path Forward

- Testing the fourth generation is underway
 - Commercial MgRich product
 - NAVAIR modified MgRich
 - Test Plan
 - Variety of substrates
 - Variety of exposure conditions
 - Beach, ASTM B117, ASTM G85 Annex 4, filliform, galvanic test panels)
 - Go/No-Go Criteria
 - Must be better than the best non-chromate coating system
 - Currently available and transitioned
 - Before implementation will be authorized for Navy and Marine Corps assets



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